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Methods of Gas Analysis.

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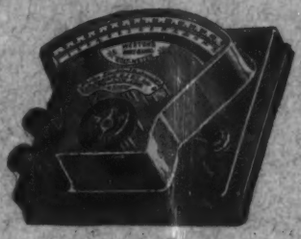

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INDUSTRIAL GAS.

BY FRANK H. BATES.

IT is only within recent years that engineers, in their efforts toward securing higher economy in fuel consumption, have directed attention to a study of the properties of gases. That such is now the case, however, is evidenced by demands which have led to the invention of such instruments as, for instance, Elliot's portable apparatus for technical gas analysis, Carpenter's calorimeter for coal, and Junker's calorimeter for gases and oils—all fashioned for the practical engineer whose time seldom permits of protracted laboratory experiments. In considering this subject, the thought occurred to the writer that the publication of a series of complete and largely original papers on "Industrial Gas" would prove of interest and value, particularly in that it appears to be but a matter of time when the gas manufacturer will supply the manufacturing world with gaseous fuel.

Without further preface, the subject will be treated under the following general divisions:

I. Methods of Gas Analysis.
II. Heating Value, or Calorific Power.
III. Fuel Gas Analysis, with a view to increasing Furnace and Boiler Efficiency.
IV. Methods of Production.

I.—METHODS OF GAS ANALYSIS.

Apparatus. For furnace and chimney gases, consisting principally of carbon dioxide, carbon monoxide, oxygen and nitrogen, by far the most convenient apparatus is the Orsat, (Fisher's modification) arranged in a portable case.

For furnace or chimney gases, producer gas, and illuminating gas, where great accuracy may be sacrificed to rapidity of operation and convenience, Elliot's latest modification with explosion burette, half size, and arranged in a traveling case, is suitable.

For accurate laboratory analysis, use Hemple's apparatus.

It sometimes happens that one is so situated as to make it desirable to obtain a rough estimate, or an approximation, of the constituents of a gas, there being no standard apparatus at hand. In such event, the tubes illustrated in Figure 1 can be quickly made up from plain glass tubing, of about 20 millimeters* (¾ inch) internal diameter. First bend and draw out the projecting end *d* of the tube A, retaining the conical form and making the external diameter about 4.7 millimeters (3/16 inch). Make the glass tube *d* corrugated so as to permit a rubber tube to be securely fastened thereon by wire, and have the tube *d* project from the main tube some 38 millimeters (1½ inches) thus providing for the wooden stand *e*, which is to be slotted to allow of its receiving the tube, and of the latter being secured thereto by a clasp. This finished, cut the glass tube off to a length of about 500 millimeters (20 inches), and shape the end *c* down to an internal diameter of about 0.8 millimeters (1/32 inch). Make this end 32 millimeters (1.25 inches) in length, and form its outside to correspond to the end *d* for a rubber tube connection. Next make up the tube A' of similar diameter but one-third longer. The projection *d'* is identical with *d*, but

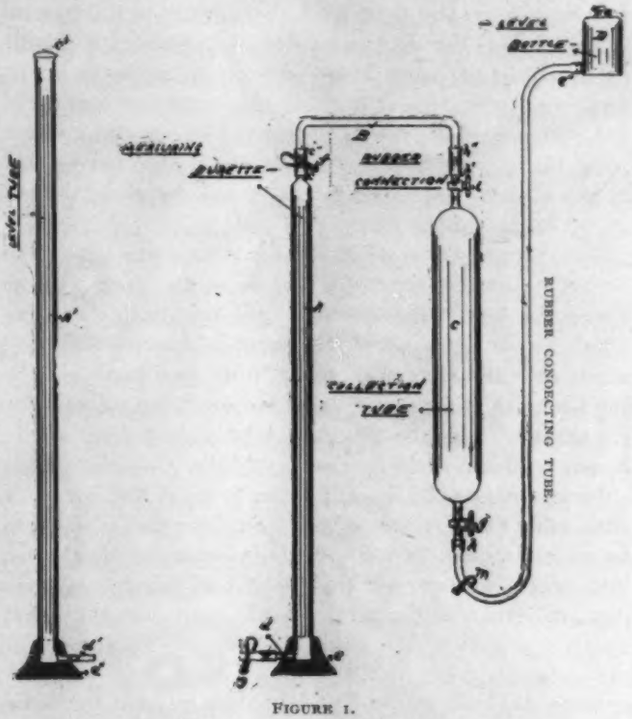

FIGURE 1.

at *c'* the tube, instead of being conically drawn out, as at *c*, is enlarged to a funnel shape, forming a mouth for the reception of liquids.

Having this complete, fasten a piece of seamless rubber

* To reduce millimeters to inches, multiply by .03937, or divide by 25.4.

tubing on the end *c* of the tube A by wire ligatures, leaving some 40 millimeters (1.5 inches) of the tube length above the glass for the purpose of inserting a connecting piece thereon. Fasten the end of a piece of rubber tubing one-half meter (19.6 inches) long to the projection *d*, and a similar piece to the end *d'*, connecting the two free ends by a piece of glass tubing, thereby obviating the necessity of removing the wired ends at *d* and *d'* when cleaning the tubes. The tube A, which is termed the measuring burette, is thus connected to tube A', termed the level-tube.

To calibrate A, proceed as follows: First ascertain the amount of water contained by, say, 325 millimeters of the length of the tube A'. In this instance, as the internal diameter of the tubing is 20 millimeters, the quantity would be 102.102 cubic centimeters,* or each millimeter of the length of the tube would contain about 0.31416 cubic centimeters. Now fasten a thin strip of paper, scaled to millimeters, and about 400 millimeters in length, on the outside surface of the tube A', to serve temporarily. Place a pinch-cock, *f*, on the rubber tube close to the end *c*, and place another pinch-cock, *g*, in a similar manner on the rubber tubing close to the end *d*. With both pinch-cocks open, fill the two tubes with water, having the water overflow at the end of the rubber tube *c*, the capillary tubing B not being attached as yet; then close the pinch-cocks *f* and *g* and partially empty the level-tube A' so that the level of the water is a little above the lowest reading of the paper scale. Open the pinch-cock *g*, then by raising the level-tube A' so that the water in it will be on the same level as the water in the burette A (which is at the very top or end *c*), the contents of both tubes will be under equal pressure; *i. e.*, under equal atmospheric pressure. Notice at this time the reading of the water level in the level-tube A' on the improvised scale, taking care to read the position of the lowest point of the sharply defined, crescent-shaped meniscus formed at the surface of the water.

For the purpose of illustration, consider this reading to be 10 millimeters from the bottom of the scale. Now lower the level tube A', and open the pinch-cock *f* to admit air so as to allow the water in burette A to drop about 42 millimeters (1.6 inches) from its former level—the top of the tube at *c*. After waiting three minutes for the walls of the tube to drain, take the reading of the water level on the scale on level-tube A', under atmospheric pressure, by bringing the level of the water in both tubes to the same height. Suppose the reading to be 20 millimeters, then 20—10 (the former reading) = 10 millimeters, and as each millimeter was found to contain 0.31416 cubic centimeters, 10 millimeters would equal 10×0.31416 or 3.1416 cubic centimeters, the amount of air admitted.

Keep the level of the liquid in both tubes at the same height and then mark the line of water level on the burette A with a file. Now, in a similar manner as before, admit sufficient air to make a total of 100 cubic centimeters, which in the present case, would correspond to 318.3 millimeters in the scale of the level tube. In doing this no difficulty need be experienced if care is taken to admit very little air as the required amount (100 cubic centimeters) is approached. The level-tube A' should be raised frequently to make the readings until about the amount is obtained when three minutes should be allowed to drain the water from the walls of the burette before making the final measurement.

Now with the liquid in the level-tube A' and in the burette A at the same height, mark with a file the level of the water in burette A. This corresponds to 100 cubic centimeters, measuring from the top at *c*. Cut a strip of paper of a length equal to the distance between the two file marks, and on this paper lay off a scale in proportion, divisioning it into tenths of cubic centimeters, gluing it on to the measuring burette A and shellacking. The scale on the level-tube A', may now be discarded, and there has been thus improvised an apparatus that, in lieu of a better one, will suffice for rough work.

Operation. The pinch-cocks *f* and *g* are first opened by simply slipping them off over the ends of the glass tubes *c* and *d*, and they remain so. Water is poured into the mouth *c'* of the level-tube A', until it overflows from the short rubber tube on *c*, when the pinch-cocks *f* and *g* should both be closed. During the operation of filling with water, the level-tube A' should be held at such a height with respect to the burette A, that it may fill the former about two-thirds full. Now make connection with the collection tube C, containing the gas sample, by means of the capillary tube B, which should be as short as possible and bent at right angles at a point about 30 millimeters from each end. In joining the capillary tube B, first prepare it by filling with water and wiping a little vaseline over the ends *c''* and *h''* where the rubber tube connections are to be attached. By means of a small dropping pipette also fill the short pieces of rubber tubing in the ends *c* and *h'* of the burette and collection tube respectively, and by slipping one end of the capillary tube into the rubber tube at *c* and the other end into the end of the rubber tube at *h'*, all air will be excluded. The end *k* of the collection tube C should be connected by a piece of rubber tubing a meter (39.37 inches) long to the level-bottle D, after which slip a pinch-cock *m* on the rubber tube near *k*.

The above connections having been made, next place the level-tube A' on the floor with burette A resting on a stand, and raise the level-bottle D to a support arranged above the collection tube C. Open the pinch-cocks *g*, *f* and *m* and the glass-cock *j* in the collection tube C, thereby putting the collection tube C and level-bottle D in connection. By opening the glass cock *i* the pressure of the column of water between the collection tube and the level-bottle will force the gas over into the burette A, and in this it will be assisted by the expansion of the water in A, due to the relatively low position of level-tube A'. Pass over about 50 cubic centimeters of gas, close the glass-cock *i*, and agitate the water in the burette vigorously in order that it may become saturated with the gas. Next open the glass-cock *i*, raise the level-tube A' and lower

* To reduce cubic centimeters to cubic inches, divide by 16.383.

level-bottle D, causing the gas to return to the collection tube. Again agitate the collection tube, after which transfer the gas back and forth a few times, thoroughly saturating the water in both the level-bottle and level-tube, to prevent the water washing out the soluble constituents of the gas when making the analysis.*

This preliminary operation complete, force all the gas from the burette A by raising the level-tube A′ and lowering the level-bottle D. Close the pinch-cocks *f* and *m* and the glass-cocks *i* and *j*, and disconnect the rubber tubing of the level-bottle D from the collection tube—the pinch-cock *m* serving to prevent the out-flow of water; also remove capillary B from both the collection tube and burette. Fill the short rubber tube at *c* and the capillary tube B with water, and after wiping the ends of the latter with vaseline, make connections with a new collection tube, containing sample gas.

One is now ready to proceed with the analysis proper.

Analysis. By lowering the level-tube and raising the level-bottle, opening pinch-cocks *f* and *m* and glass-cocks *i* and *j*, about 103 cubic centimeters of gas is admitted to the burette, when pinch-cock *f* and glass-cocks *i* and *j* are closed, the capillary tube disconnected, and, together with the collection tube and level-bottle, laid aside. Close pinch-cock *g* and place level-tube on the support above, thereby creating a pressure due to the weight of the water column above the water level in the burette. After waiting three minutes for the walls of the burette to drain, open pinch-cock *g* just sufficient to allow the lowest point of the meniscus of the water to rise to the 100 cubic centimeter mark in the burette, taking precaution to have the eyes on the same level. There is now contained in the burette 100 cubic centimeters of gas under pressure a trifle greater than atmospheric. Open pinch-cock *f* to the air for but a moment, thus allowing the excess pressure to escape. By now opening pinch-cock *g* and holding the level-tube so that the surface of the liquid therein will be on the same level with the liquid in the burette, thus putting our gas under atmospheric pressure, the level in the burette will be found to coincide with the 100 cubic centimeter mark.

In these illustrations, 100 cubic centimeters of gas is taken to simplify matters, as the readings thus give percentages direct.

Determination of Carbon Dioxide. We first determine the quantity of carbon dioxide (chemical formula CO_2) by absorption with a reagent.† The reagent used as an absorbent may be potassium hydroxide, sodium hydroxide, or barium hydroxide. The first is to be preferred, owing to its quick action, but the last is employed to advantage when the quantity of carbon dioxide is very small.

To treat the gas with the reagent, lower the level-tube to expand the gas in the burette until the level of the water lowers almost to the top of foot-piece *e*; then close pinch-cock *g*, and empty the level-tube and tubing of water and then partially replace it with the absorbent. Raise the level-tube with the left hand as high as the rubber tubing permits, when, by opening pinch-cock *g*, a considerable quantity, diluted with the water left in the rubber tubing, will be forced into the burette. Lowering and raising the level-tube will thoroughly mix the reagent and the water and assist in the absorption of the carbon dioxide. By closing pinch-cock *g* and agitating the burette, all the gas will be brought into intimate contact with the absorbent. Note the readings from time to time, and when no further diminution of volume takes place, open pinch-cock *g*, and after waiting three minutes for the walls of the burette to drain, measure the gas volume under atmospheric pressure by bringing the level of the liquid in both tubes to the same height. This reading, subtracted from 100, will give the per cent. by volume of carbon dioxide in the gas.

Determination of Illuminants. Again lower the gas in the burette as much as possible, and in doing so, exercise the same care as before in order to prevent the liquid in the burette from dropping too low lest the gas gets into the tube and escapes. Then close the pinch-cock *g*, and empty the level-tube of the reagent, afterwards rinsing out with water. Next, add a little water in which a few drops of hydrochloric acid was previously mixed, to neutralize the remaining reagent in the lower portion of the burette.

The next determination is that of the illuminants or heavy hydrocarbons. These consist principally of ethylene, (furmula C_2H_4) the absorbent for which is bromine water. The level tube is nearly filled with water and a little bromine is added with a dropping pipette. The gas residue is then treated with this reagent as in the previous case until no further action takes place. In the present instance, however, before measuring the amount of absorption, it will be necessary to empty the level-tube of the bromine water, first closing pinch-cock *g*, and then partially replacing, not with the next reagent, but with potassium hydroxide, with which treat the gas. This is necessary after using bromine, owing to its high tension, or tendency to vaporize. The potassium hydroxide absorbs this vapor, after which the gas may be measured and the true percentage of ethylene may be ascertained by direct reading.

Determination of Oxygen. Again lowering the gas in the burette and emptying the level-tube, rinse and partially fill with potassium pyrogallate for the absorption of oxygen, (symbol O). The method of treatment in this case is similar to the preceding, except that no vapors are formed, and, in consequence, treatment with potassium pyrogallate alone suffices.

Determination of Carbon Monoxide. The percentage of oxygen determined, empty the level-tube, rinse with water, and add the next absorbent, cuprous chloride, for the absorption of carbon monoxide, (formula CO). This is our last determination with this apparatus. An example may serve to illustrate the foregoing operations.

Partial analysis of Donson producer gas:

The water in level-tube and level-bottle was saturated with the gas.

* With the present apparatus this is almost a useless precaution, but is given to familiarize the reader with principles to be followed in more exact analyses.

† Most of the constituents of coal gas may be removed or absorbed by certain liquid reagents, there being exceptions, however, such as hydrogen, methane, nitrogen, etc., which are removed by combustion.

From another collection tube 100 cubic centimeters of the sample gas was taken for analysis.

After treating with potassium hydroxide until no further absorption took place, the gas volume measured 93.43 cubic centimeters; hence, 100—93.43=6.57 cubic centimeters, the amount of carbon dioxide in 100 cubic centimeters of sample gas, or, carbon dioxide is 6.57 per cent.

Level-tube emptied, rinsed with water, and a little hydrochloric acid added to neutralize the potassium hydroxide. Gas is treated with bromine water until absorption is complete, level-tube then emptied, rinsed, and partially filled with potassium hydroxide to absorb the bromine vapors. Gas volume then measured 93.12 cubic centimeters; hence, 93.43 (last reading) —93.12=0.31 cubic centimeters, the amount of ethylene in 100 cubic centimeters of sample gas, or, ethylene is 0.31 per cent.

Level-tube emptied and rinsed, and without adding hydrochloric acid, gas is treated with potassium pyrogallate until no further absorption, and volume then measured 93.09 cubic centimeters; hence, 93.12 (last reading) —93.09=0.03 cubic centimeters, the amount of oxygen present in 100 cubic centimeters of sample gas, or, oxygen is 0.03 per cent.

Level-tube emptied, rinsed, and gas treated with cuprous chloride until no further absorption. Gas volume was 68.02 cubic centimeters; hence, 93.09 (last reading) —68.02=25.07 cubic centimeters, the amount of carbon monoxide present in 100 cubic centimeters of sample gas, or, carbon monoxide is 25.07 per cent.

Other constituents of the gas could not be determined with this apparatus. They must be determined by combustion, as will be shown later. This apparatus would suffice, however, for furnace or chimney gases composed of carbon dioxide, oxygen, carbon monoxide, and nitrogen. The nitrogen in this case would be found by difference; *i. e.*, by subtracting the sum of the other gases from 100, which would give its percentage.

Properties of the Gases. CARBON DIOXIDE. Synonyms: carbonic acid gas, fire-damp, after-damp, etc. Formula CO_2. Molecular mass (generally termed weight), 44; more correctly, according to atomic weights of Meyer and Seubert, 43.89. Specific gravity compared to air, 1.5290. Weight of one liter, 1.977 grams; weight of one cubic foot, 0.12343 pounds.

An irrespirable, colorless gas, denser than air, having a pungent odor, and acid taste. It is fatal to animal life extinguishes combustion. At normal conditions of temperature and pressure (0 degree C. and 760 millimeters of mercury) water absorbs or dissolves about one volume of carbon dioxide; as the pressure increases, temperature remaining constant, a greater absorption takes place, an additional volume being absorbed for each atmosphere of pressure added. Carbon dioxide becomes liquid at a pressure of 38.5 atmospheres and 0 degree C., with a specific gravity of 0.923. At —65 degrees C., the liquid solidifies to a transparent mass like ice. A temperature of —140 degrees C. may be obtained by means of frozen carbon dioxide moistened with ether and placed in a vacuum.

Preparation: Carbon dioxide may be prepared by the action of an acid upon some carbonate:

$$\underset{\text{Calcium Carbonate}}{C_aCO_3} + \underset{\text{Nitric Acid}}{(HNO_3)_2} = \underset{\text{Calcium Nitrate}}{C_a(NO_3)_2} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon Dioxide}}{\uparrow CO_2}$$

ETHYLENE. Synonyms: olefiant gas, ethene, hydrogen di-carbide. Formula C_2H_4. Molecular mass 28; according to Meyer and Seubert, 27.94. Specific gravity compared to air, 0.9847. Weight of one liter, 1.273 grams; weight of one cubic foot, 0.07949 pounds.

An irrespirable, colorless gas, with odor of ether. Soluble in about eight times its volume of water. Combustible, emitting a brilliant white flame when burning in air, and evolving much smoke. Mixed in the proportion shown in formula below (one volume of ethylene to three volumes of oxygen), explodes violently on ignition. At 9.8 millimeters pressure, its evaporation produces a temperature of —150.4 degrees. It is the principal constituent of the fixed illuminants or heavy hydrocarbons.

The reaction with oxygen is:

$$C_2H_4 + 3O_2 = 2CO_2 + 2H_2O$$

One volume of ethylene + three volumes of oxygen unite to form two volumes of carbon dioxide and two volumes of water, but the water may be considered as possessing no volume (owing to contraction in changing from a gaseous to liquid form), consequently the contraction due the combustion of ethylene is $2C_2H_4$; 1 volume +3 volumes=4 volumes; 4—2=2 volumes contraction, or, for every volume of ethylene burned there is a resulting contraction of two times the volume of ethylene, or, contraction equals $2C_2H_4$. A reference to the reaction also shows that two volumes of carbon dioxide are formed for each volume of ethylene burned, or the carbon dioxide formed equals two times the ethylene burned; $CO_2=2C_2H_4$.

Preparation: Ethylene may be prepared by the action of sulphuric acid upon alcohol: $C_2H_6O=\uparrow C_2H_4+H_2O$.

OXYGEN. Symbol O. Atomic mass, 16; or, according to Meyer and Seubert, 15.96. Valence II. Molecular mass, 32; or, according to the atomic weight of Meyer and Seubert, 31.92. Specific gravity compared to air, 1.1051. Weight of one liter, 1.4298 grams. Weight of one cubic foot, 0.08948 grams.

Oxygen is respirable when pure, accelerating the respiration; a colorless, odorless, tasteless gas, of greater density than air, and slightly soluble in water, 100 volumes of water at 0 degree C., taking up 4.1 volumes of oxygen. The union of any element with oxygen is what is generally implied by combustion. The action of oxygen in air is much less active in such union than when pure, owing to the dilution with nitrogen. Combustion with oxygen is attended with light and heat. Oxygen becomes liquid at 20 atmospheres of pressure, at a temperature of —136 degrees Fahrenheit.

Preparation: Oxygen may be prepared by heating potassium chlorate, mixed with one-quarter of its weight of manganese dioxide:

$$(K\,CL\,O_3)_2 + MNO_2 = (K\,CL)_2 + MNO_2 + \uparrow(O_2)_3$$

CARBON MONOXIDE. Synonyms: carbonic oxide, car-

bonyl. Formula, CO. Molecular mass, 28; according to Meyer and Seubert, 27.93. Specific gravity compared to air, 0.9674. Weight of one liter, 1.251 grams. Weight of one cubic foot, 0.07810 pounds.

It is an irrespirable, colorless gas, with suffocating odor. One per cent. in air proves fatal to life. Combustible, burning with a blue flame. It is a constituent of water gas, made by passing steam over incandescent fuel, and has, in this connection, been the topic of much discussion and even legislative interference, owing to the difficulty of detection and fatal effects on life. It is condensible to a liquid at —139.5 degrees C., and 35.5 atmospheres.

The reaction with oxygen is $CO + \frac{1}{2}O_2 = CO_2$.

One volume of carbon monoxide combining with one-half volume of oxygen forms one volume of carbon dioxide; or, the contraction is $1\frac{1}{2} - 1 = \frac{1}{2}$ or $\frac{1}{2}CO$. The carbon dioxide formed equals the volume of carbon monoxide burned, or $CO_2 = 1CO$.

Preparation: Carbon monoxide may be prepared by heating oxalic acid with strong sulphuric acid:

$$\underset{\text{Oxalic Acid}}{H_2C_2O_4} = \underset{\text{Water}}{H_2O} + \underset{\text{Carbon Dioxide}}{CO_2} + \underset{\text{Carbon Monoxide}}{\uparrow CO}$$

As seen, CO_2 is also present in the products, but can be removed by treating with potassium hydroxide, absorbing it as in gas analysis.

NITROGEN. Symbol N. Atomic mass, 14; according to Meyer and Seubert, 14.01. Valence I, III, and V. Molecular mass, 28; according to atomic mass of Meyer and Seubert, 14.02. Specific gravity compared to air, 0.9714. Weight of one liter, 1.2561 grams; weight of one cubic foot, 0.07842 pounds.

Nitrogen is an irrespirable (it exerts no injurious action upon animal tissue, but does not support life), colorless, odorless, and tasteless gas of less density than air, slightly soluble in water, 2.5 volumes being absorbed by 100 of water. It is inert as regards combustion, uniting with oxygen only at an elevated temperature. Cooled to —150 degrees C., in liquid ethylene, boiling under a pressure of 10 millimeters; nitrogen is liquefied by a pressure of about 30 atmospheres.

Preparation: Nitrogen may be prepared by heating ammonium nitrate:

$$\underset{\text{Ammonium Nitrate}}{(NH_4)\,NO_3} = \underset{\text{Water}}{(H_2O)_2} + \underset{\text{Nitrogen}}{\uparrow N}$$

Preparation of the Reagents Employed. POTASSIUM HYDROXIDE. Dissolve 500 grams of commercial hydroxide (which has not been purified by alcohol) in one liter of pure water. It is ready for use as soon as made. Capacity: One cubic centimeter absorbs 40 cubic centimeters of carbon dioxide.

SODIUM HYDROXIDE. Make a saturated solution of the commercial hydroxide in pure water.

BARIUM HYDROXIDE. Make a saturated solution of barium oxide in water, (the barium oxide slakes).

Of these reagents, the first is preferable owing to its rapidity of action, the second to its cheapness, and the third to its accuracy where the carbon dioxide is in small quantities.

BROMINE WATER. Made by adding a little bromine to a liter of water, very little being required to saturate the water, causing it to give off bromine vapors.

POTASSIUM PYROGALLATE. To 50 grams of pyrogallic acid add 1000 cubic centimeters of potassium hydroxide as made above. Keep well corked owing to its affinity for the oxygen of the air. It is ready for use as soon as made. Capacity: One cubic centimeter absorbs two centimeters of oxygen.

CUPROUS CHLORIDE: Place in a liter reagent bottle 300 grams of copper oxide, and on this arrange a bunch of copper wire to reach the entire length of the bottle. Then fill with hydrochloric acid (specific gravity 1.10). The bottle is shaken, well corked to prevent the absorption of oxygen, and allowed to stand in the dark till perfectly clear, when it is ready for use. Exposure to light will cause it to assume a brownish color, which does not affect its action, however. Capacity: One cubic centimeter absorbs one cubic centimeter of carbon monoxide.

Examination of Furnace or Chimney Gases by means of the Orsat Apparatus. With the apparatus already considered, the gas was drawn into a measuring burette and successively treated by the absorbents, which (in the case of potassium pyrogallate and cuprous chloride), owing to exposure to the oxygen of the air during the treatment, could be used but a few times before their powers of absorption became exhausted.

Orsat devised an apparatus whereby the reagents are protected from the air, and in which the gas itself is brought in contact with the absorbents. It is only to be regretted that the scope of the apparatus is so limited. It offers, however, a most convenient means for the determination of carbon dioxide, oxygen, and carbon monoxide by absorption, and nitrogen by difference, these being the gases found as constituents in furnace and chimney analyses.

Description. Consists of three double pipettes, B, C, and D, Figure 2, made stationary in the case and connected by means of capillary tubing to a measuring burette A, enclosed by a water jacket. Glass stop-cocks E, F, and G close each pipette to the main capillary, and the glass stop-cock H, thereon, affords an inlet for air from the end J. A level-bottle L, provides a means of transferring the gas. To the rear of the pipettes B, C, and D, and connected by glass tubing, are three similar pipettes, whose ends, s, s', and s'', are connected by rubber tubing with a small, flexible rubber bag, which acts as a seal, preventing the absorption of oxygen from the air by the reagents in the pipettes. The water-jacket may, under ordinary conditions, be simply filled with water, which will tend to prevent slight changes of temperature affecting the gas volume. When the apparatus is so situated as to be subject to draughts or sudden changes, —although this should be avoided when possible—connections should be made with the water supply, so as to have a circulation of water in the jacket, which will secure a fairly even temperature.

Figure 2 shows Fisher's modification of the Orsat,

which is of small size and arranged for convenience in traveling.

Figure 3 shows a slight modification known as Petrizilka's, with one universal stop-cock, dispensing with the four small ones.

Manipulation. The level-bottle L is filled with pure

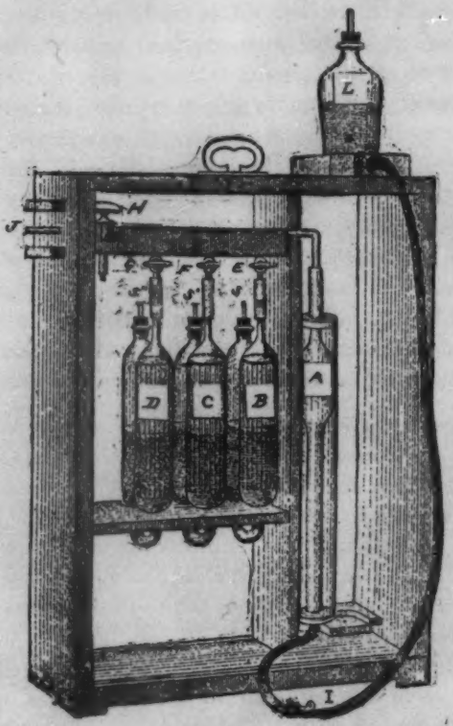

FIGURE 2.

water, and with stop-cocks E, F, and G closed, and H opened, the measuring burette is partly filled by raising level-bottle L, forcing air through the exit J. By closing stop-cock H and lowering level-bottle L, the air remaining in the burette and capillary is expanded, so that on opening stop-cock E, the reagent in pipette B will be drawn up to a point just below the connecting rubber M, when stop-cock E is closed and the reagents in pipettes C and D similarly raised to corresponding positions. This done, open stop-cock H, and by raising level-bottle L, force all the air from both the burette A and the capillary tubing, displacing by water which will overflow from the end of capillary at J, when close stop-cock H.

Preliminary to the analysis proper, make connections with a collection tube of sample gas and the end J, of capillary tubing of the apparatus, taking same precautions as before to expel all air from the rubber tube and connecting tube, if one is used. Draw in about 50 cubic centimeters of gas (there is contained 100 cubic centimeters from the stop-cock H in the capillary tube, to a point marked 100 cubic centimeters near the bottom of the burette, and the graduations are in tenths of cubic centimeters), by lowering level-bottle L. As soon as the gas is admitted, close stop-cock H, and raise and lower the level-bottle to cause the gas to come in through contact with the water, thus saturating the latter with the absorbable constituents of the gas. Open stop-cock H and expel the gas, filling completely the burette and capillary with the saturated water, and on its overflowing at J close the stop-cock H. We are now ready for our sample for analysis, so draw in through end J, in a similar manner, a little more than 100 cubic centimeters,—say, for instance, 101 cubic centimeters—closing stop-cock H immediately on securing that amount. Wait one minute for the walls of the burette to drain, and then close the pinch-cock I on the rubber tube connecting the level-bottle and the burette, close to the latter. By raising the level-bottle L, a pressure is created, due to the height of the column of water, so that on gradually opening the pinch-cock I, the gas is forced up in the burette. With the eyes on the level of the 100 cubic centimeter mark on the burette, close the pinch-cock I just as the lowest point of the meniscus reaches the mark, when we will have 100 cubic centimeters of gas at little more than atmospheric pressure. By opening the stop-cock H for but a moment, this excess will escape to the air, leaving us exactly 100 cubic centimeters of gas. By opening pinch-cock I and bringing the level-bottle L to such position that the level of the liquid contained corresponds to the level of the liquid in the burette, we will find that the level in the burette will be at the 100 cubic centimeter mark, proving the amount of gas contained to be 100 cubic centimeters at atmospheric pressure.

Determination of Carbon Dioxide. We may now treat our gas to the first absorbent, potassium hydroxide, which is contained in pipette B. Opening stop-cock E and raising level-bottle L, forces the reagent down and up into the rear pipette, laying bare the contained tubes, wet with the reagent, thus exposing a large absorbing surface. This reagent quickly absorbs the carbon dioxide present

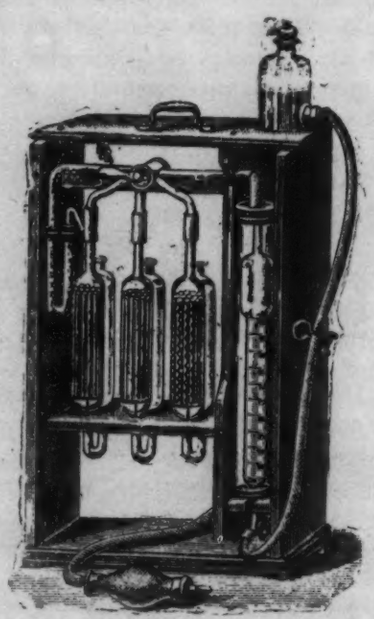

FIGURE 3.

in the gas, one passage of the gas into the pipette generally proving sufficient. By raising and lowering the level-bottle a few times all the gas is brought into thor-

ough contact with the absorbent, and can then be drawn back into the burette for measurement by lowering the level-bottle L, closing stop-cock E, when the reagent has ascended to its former position close to the rubber connection. After waiting one minute for the walls of the burette to drain, bring the level of the liquid in level-bottle and burette to the same height, and read the position of the lowest point of the meniscus on the scale, giving the quantity of carbon dioxide absorbed. Again pass the gas into the pipette B, return to burette, (closing stop-cock E as before) and measure, after waiting one minute for burette to drain. See if this reading corresponds to the former, to make certain that the absorption is complete. This reading, subtracted from 100, the total volume of sample gas, gives the percentage of carbon dioxide.

Determination of Oxygen. The residue, or gas remaining from the last absorption, is now passed into the second pipette C, containing potassium pyrogallate, which absorbs the oxygen. Before making the final measurement, the operation should be repeated as in the previous case, to make certain that all the oxygen is absorbed. The time required will not exceed three minutes. In making the reading first allow one minute for walls of burette to drain, this being done whenever a measurement is to be made. The reading in this case subtracted from the previous one, gives the percentage of oxygen.

Determination of Carbon Monoxide. The residue is now passed into the third pipette D, containing cuprous chloride, which absorbs the carbon monoxide. A little more time should be given to this absorption, which is somewhat uncertain; say, at least five minutes. The resulting reading, subtracted from the previous one (with potassium pyrogallate), gives the percentage of carbon monoxide.

Determination of Nitrogen. Adding the percentages of carbon dioxide, oxygen, and carbon monoxide together, and subtracting the total from 100, gives the percentage of nitrogen by difference.

Special Hints. In the foregoing operations always pass the gas into the pipettes in the order named, since potassium pyrogallate, contained by the second pipette, will absorb both oxygen and carbon dioxide; and cuprous chloride, of the third pipette, both carbon monoxide and oxygen.

Before measuring and after each absorption, wait some stated interval, making it of the same duration throughout, for the walls of the burette to drain of liquid, since otherwise the readings would be in error.

The total time required will usually be about twenty minutes for the entire analysis.

An accurate account of the cubic centimeters of absorption with each reagent should be kept, and by comparing with the absorbing capacities, one will constantly know the power of the reagent, so that he may renew it as its strength becomes taxed.

No trouble need be experienced in the use of this apparatus, even by one unfamiliar with chemical work or analysis.

To be continued.

Electro-Therapeutics

THE OLD AND THE NEW IN THEORY.

DR. ECCLES, in discussing new theories in pharmacy, points out a number of mistakes which colleges of pharmacy are making in expounding doctrines of electro-therapeutics. Those of these colleges that have not adopted new doctrines, he says, are no doubt still telling their students in chemistry that water is a good conductor of electricity, a statement now known to be false. Water is practically a non-conductor. They are probably also teaching that carbon monoxide and oxygen form an explosive mixture when an electric spark is passed through them, while the new doctrine has led to the discovery that a vapor containing hydrogen must be present.* When the so-called electrolysis of water is shown to students and it is stated that it is the water which the electricity acts upon and decomposes, they are being taught that which is not true. It is the dilute sulphuric acid which is being acted upon and electrolyzed.† When medicines like potassium bromide and alkaloids are advised to be administered in the form of elixers or alcoholic solutions, the advice is contrary to the new doctrine of electrolytic dissociation.

These are but a few of the errors that are being inculcated by those not familiar with the new doctrine, but, further, new theories show why chemical reaction goes on better in aqueous solutions than in solutions of any other liquid; why syrup is a bad conductor of electricity, and dilute mineral acids or their salts good ones ("Theoretical Chemistry," p. 309); why the osmotic pressure in dilute solutions of hydrochloric acid is twice as great as in dilute sugar solutions (*ibid.*, p. 310); why dilute solutions of sulphuric have three times as much osmotic pressure as those of sugar (*ibid.*, p. 311); why a solution of $FeCl_3$ gives an osmotic pressure four times as great as sugar (*ibid.*, p. 312); why pure water and other pure substances cannot conduct electricity (*ibid.*, p. 593); why fused salts at high temperatures become conductors (*ibid.*, p. 593); why the freezing point varies in different aqueous solutions ("Outlines of General Chemistry"); why it is generally difficult to establish chemical reactions in organic compounds ("Watt's Dictionary of Chemistry," Vol. IV, p. 184); why a solution of magnesium sulphate with sodium chloride, if evaporated at ordinary temperature, will dry out as magnesium chloride and sodium sulphate, whereas if it is evaporated at a high temperature, it dries out just as what it was when put into the solution ("Outlines of General Chemistry," Ostwald, p. 276); why iron immersed in a solution of copper salt will become coated with metallic copper ("Theoretical Chemistry," Nernst, p. 612); why solutions of salts conduct electricity and solutions of many organic compounds do not ("Watt's Dictionary of Chemistry," Vol. IV, p. 191).

These examples probably suffice to show something of the scope of the light shed by the new theory. Only a beginning has been made in this direction, but it is quite promising.

ONE CANDLE-POWER PER WATT.

The similarity of materials used in the Nernst electric lamp and those used in the Welsbach mantle is well known, and now the English electrical papers call attention to a new electric incandescent lamp designed by C. Stearn, of the Zürich Electric Lamp Company, in which a mantle of refractory oxides is rendered incandescent by means of a discharge on to it of cathode rays. Mr. Stea.n claims a lighting efficiency of one candle-power for every watt of energy expended.

C. S. KNIGHT, one of the best known men in the electrical fraternity, and late vice-president of the Fort Wayne Electric Corporation, has been elected vice-president and general manager of the Siemens-Halske Company of America, and has entered upon his new duties in the general offices of the company in the Monadnock Building, Chicago.

*"Theoretical Chemistry," Nernst-Palmer, page 576.

†"Watt's Dictionary," Vol. IV, page 177.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity and Transmission of Power.

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EDITORIAL.

"FOOLS RUSH IN WHERE ANGELS FEAR TO TREAD."

Of the competition which exists in the gas business there is little to be said at present, but most of that little has been well said in a late number of the *San Francisco News Letter*, which expressed the sentiments of two-thirds of the business public of the Western metropolis when, in discussing the first annual report of the Equitable Gas Light Company, it pointed out that on February 21, 1899, the Equitable company had issued 170,500 shares of stock, which netted $190,010, or about $1.11 per share. In February last this stock sold on the board of the San Francisco Stock and Bond Exchange at $12 per share, making a profit over the amount paid in of about 1000 per cent. About 62,000 shares were sold to the Central Light and Power Company for the sum of $25,000, averaging about 40 cents per share, which stock has, within sixty days, been distributed to stockholders in the way of a dividend. Those gentlemen who received this dividend and sold their stock at $12 per share, made a trifle less than the marvelous profit of 3000 per cent. The secretary's report shows that the balance of assets on February 21st was $190,256.16, showing an apparent gain during the year of $246, but where it could have come from the report does not state. The company began delivering gas some time early in January, and up to the 21st of February, according to the same report, the total receipts from all sources other than from the sales of stock, were but $246.16. At the present market price of say, $9.00 per share, the property of the Equitable company is rated by buyers in the exchanges at something like $1,530,000, truly a magnificent increase over the sum mentioned by the secretary of $190,256.16, as being the balance of the assets of the company.

"There must certainly come a day of reckoning," continues the *News Letter*, "for those parties who are buying at this price, for, according to the latest information, the company, although having furnished gas for a period of about ninety days, and having laid a great many mains and made much newspaper talk, has still less than 130 consumers. It seems wonderful that the public is not more familiar with these facts, but we suppose it will not believe them until it finds out that it can only sell for about ten cents on the dollar what it has paid out its hard earned money for. It must be admitted that a company that can sell stock at 1000 per cent. profit need have little concern for its earnings."

On the other hand, the investor must look with only satisfaction upon the placid amicability of the relations that have for years existed between the gas interests of the San Francisco Gas and Electric Company and those of the Pacific Gas Improvement Company. They have uniform rates, do business according to uniform methods, and neither company trespasses beyond its agreed territorial bounds. Each makes gas according to its own ideas, their plants are entirely independent, and so harmonious are the relations between the two corporations that, so far as the public is concerned, they might better be under one roof, as are their gas stove departments even now. Indeed, it is probable that if the investor had his choice, he would have consolidation at once, and be done with divided operating and executive costs; but longer heads than his see the greater wisdom of the belief that in actual union there is weakness, in ostensible competition there is strength: for capitalistic San Francisco has learned well that true competition is the thief of dividends, even though the life of monetary trade.

EVOLUTION, NOT REVOLUTION, IS AT HAND.

The word of admonition given by Alexander Siemens to the Society of Arts at the conclusion of the discussion of the paper by James Swinburn on the Nernst lamp has found unexpected endorsement. It seems that the exploiters of the Nernst patents have issued a prospectus before the English public inviting applications for £115,000 in 7 per cent. non-cumulative shares of which the vendors take £90,000, in addition to the whole of the ordinary share capital of £180,000. Commenting on this a London contemporary states that this seems a high price to pay for an invention which is in an experimental stage, especially when it is remembered that the countries for which the company secured patent rights (not yet granted in most cases) do not include any European country, North America, or Canada. The prospectus further says that the greater part of the European rights for the new lamp are controlled by the Allgemeine Electricitaets Gesellschaft, but it does not tell that this company, in its last report, said that "it is not expected that the Nernst lamp will displace to any great extent the ordinary glow lamp," nor does it tell that the sum the Berlin company paid for the German patents has already been written off.

Evidently the principal electrical manufacturing company of Germany can discern no revolutionizing feature in the Nernst invention, despite the claims that it possesses the remarkably high lighting efficiency of 1.5 watts per candle-power.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

MINING IS ITS ELEMENT.

A prominent western mining journal which has coupled an electrical clause to its headline, makes an astonishing misstatement in a recent issue concerning one of the fundamental laws of electricity. The contemporary states:

> The transmission of electric energy is subject to the same laws of resistance as gases. When a powerful electric current is transmitted through a conductor, if it be desired to reduce the resistance, the voltage or electric pressure is increased; as the higher the voltage, the lower the resistance, and, conversely, the higher the amperage or electric quantity, the greater the resistance. A statement that includes electrical transmission and the transmission of fluids may thus be made: The resistances vary inversely as the pressures, and directly as the losses.

Electricians will be quick to recognize the ridiculousness of the above interpretation of Ohm's law, but charity to the layman calls for a statement that will disabuse his mind of the false notions there given. After boiling it down, sifting it out, and seasoning it with the veriest rudiments of electricity, (for the excerpt given obviously purports to be naught else) it is believed that what our contemporary intended to say was that the transmission of electric energy by direct currents is subject to laws not unlike those which determine the losses in pressure resulting from the transmission of gases through pipes. When a given amount of electrical energy is to be transmitted through a conductor, if it be desired to reduce the losses consequent thereto without increasing the size of the conductor, the voltage is increased; as the higher the voltage, the lower the line loss or drop in voltage resulting from the transmission. Conversely, the higher the amperage, the greater the loss under the given condition.

It may be added that amperage does not express "electric quantity;" it is the term used to denote the *rate of flow*, and, as such, is analogous to miners inches. "Electric quantity" is expressed in coulombs, and, as such, is analogous to gallons.

There is to be no charge to our otherwise valued contemporary for this tutelage.

* * *

THE "WORLD" AND "ENGINEER" COMBINED.

The surprise of the year in technical journalism has been the combination that has been effected between *The Electrical World* and *The Electrical Engineer*, by which the two leading electrical journals of America will henceforth appear as *Electrical World and Electrical Engineer*, under the editorship of T. Commerford Martin and W. D. Weaver, and the business management of James M. Wakeman, late of the *American Machinest*, and A. C. Shaw. There are none in electrical journalism whose abilities are more universally recognized or more highly esteemed than those of Messrs. Martin and Weaver, and it is but mild endorsement to say that America's leading weekly electrical publication could not possibly be in better editorial hands. Equally true is it that the electrical public will feel keenly the loss of the writings of Joseph Wetzlar, late co-editor of *The Electrical Engineer* with Mr. Martin, and who, in a farewell editorial note in the last issue of that journal, announces that hereafter he will devote himself entirely to The Electrical Engineer Institute of Correspondence Instruction. Similarly too, W. J. Johnston, proprietor of *The Electrical World* since its inception twenty-five years ago, announces his retirement from electrical journalism, and in doing so he should certainly feel proud satisfaction in the realization that his labors have builded the most influential electrical periodical the world has ever known. The consolidation was effected through James H. McGraw, of the *Street Railway Journal*, and his associates.

* * *

INEFFICIENCY OF INCANDESCENT LAMPS.

Judging by the criticisms received, there are many who have read with considerable surprise the assertions appearing in these columns concerning the woeful inefficiency of the incandescent electric lamp as a light-giving agency, in view of which it may be well to publish the confirmatory opinion of Gilbert S. Ram, in his valuable work on "The Incandescent Lamp and Its Manufacture," where, on pages 210 and 211, he states: "At a temperature of four watts per candle-power, it has been estimated by actual experiment, that the proportion of luminous radiation in an incandescent lamp is about five per cent. only, while the proportion in the case of an arc lamp is about ten per cent. . . . . The ideal lamp is one from which the radiation is wholly luminous. The carbon incandescent lamp is, therefore, very far indeed from attaining the ideal standard. A more efficient lamp must be looked for in another direction."

* * *

A GENERAL FORMULA FOR TRAIN RESISTANCE.

A new general formula for train resistance, with diagrams and a table showing the closeness with which the results obtained thereby agree with actual tests, is given in an editorial appearing in the *Street Railway Journal*, February issue, and the digestion of this editorial by all who are interested, is commended.

The formula, which is due to John Lundie, consulting engineer of the South Side Elevated Electric Railway, is as follows:

$$R=4+S\left(0.2+\frac{14}{35+T}\right)$$

where

T=the weight of the transportation unit in tons (2000 pounds).

R=resistance in pounds per ton.

S=speed in miles per hour.

The publication quoted endorses the formula as appearing to be applicable to "*passenger* trains of all weights, running at all speeds up to the highest limit so far reached," and describes that Mr. Lundie's method of determining train resistance is based on an examination of the speed curves of a train when coasting from any speed to a dead stop. It does not check the most recently obtained data for exceedingly heavy freight trains.

Gas

THE WESTINGHOUSE GAS ENGINE.*

BY EDWIN RUUD.

GAS engine engineering is a peculiar and difficult line, probably one of the hardest branches in the entire mechanical field of today. This you will understand when you stop to consider that the temperature in the cylinder during the explosion periods is a dazzling white heat, and that many parts are exposed to this high temperature. Add to this the different behavior of the various kinds of gases, and that the whole process is going on within closed doors, so to speak, where you have very little chance to see what is taking place, and you can imagine the difficulties of the problem. It is a wonder that an engine can be made to run satisfactorily under such conditions. It requires a constant association with the subject in order to fully understand and to be able to overcome the numerous difficulties which present themselves. The difficulties increase with the size of the engine, due to the fact that the heat problem becomes more and more troublesome to solve. It is for this reason that the gas engine has not made much headway in the larger sizes. Also, few men have been willing to experiment in large sizes of gas engines, in view of the uncertainty and the abnormally heavy expense connected with the development of, say, a 1000 horse-power gas engine. I shall later on say a few words touching upon large-size gas engines.

I shall, in the course of this short talk, confine myself to two classes of engines now in use, and shall endeavor to explain or make clear to you the workings of these two kinds of prime movers. This classification is made with regard to the mode of regulation, the cycle being the same in both the "Otto" or "Beau de Rochas;" in fact, this cycle is about the only one used today commercially. I shall try to point out the advantages and the disadvantages of these two classes in order. But before I do this, I shall explain the working or principle of the gas engine in general for the benefit of the members who may not be familiar with the underlying principle. (Here the lecturer made some sketches on the blackboard and explained the first principles of design in the gas engine.) The so-called "hit-and-miss" gas engine has been made exclusively until recently, and I shall therefore describe this style first.

The phrase "hit-and-miss" is admirably well adapted for this type, as you will see.

Figures 1 and 2 illustrate the principles involved in this mode of governing.

The cam shaft *A*, Figure 1, which operates the exhaust valve *J* and other parts, runs only half the number of turns that the engine does. On this shaft is fastened the cam *B*, which moves the gas valve *G* when the roller *C* is brought in the proper position so as to ride on the cam. The governor *D* controls the position of this roller by aid of the bell crank lever *E*. Thus, if the speed of the engine is too low, the governor balls will ride closer to the spindle, and this will raise the governor sleeve *F*, thus operating the lever, which moves the roller *C* on its spindle to a position where the cam will strike it, raising gas valve *G* and permitting the gas to be drawn to the inlet valve *H*, where it mixes with the air as it enters the cylinder of the engine. On the return stroke of the piston the charge is compressed and ignited at dead center. Now comes the expansion stroke and then the exhaust valve *J* is opened, and on the return stroke the products of combustion are expelled.

You will see that by this mode of governing one or more charges may be cut out, and that the engine either takes in a full charge of gas and air or omits the gas altogether, as the gas valve stem is only in position to be operated by cam *B* when the engine is running at or below normal speed.

Thus you will readily understand why the "hit-and-miss" type of engine is not suitable where a uniform speed is required, and but few of this type are running in connection with dynamos for lighting purposes. Where they are driving dynamos it is generally done as indicated in Figure 3.

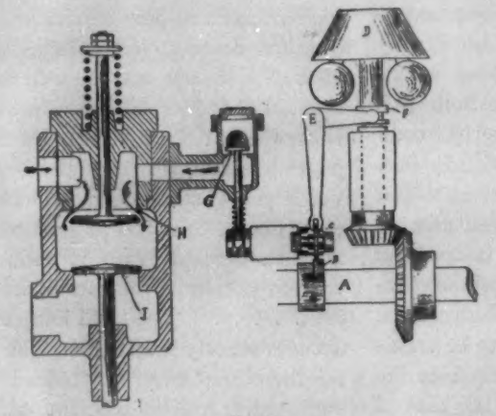

FIGURE 1.

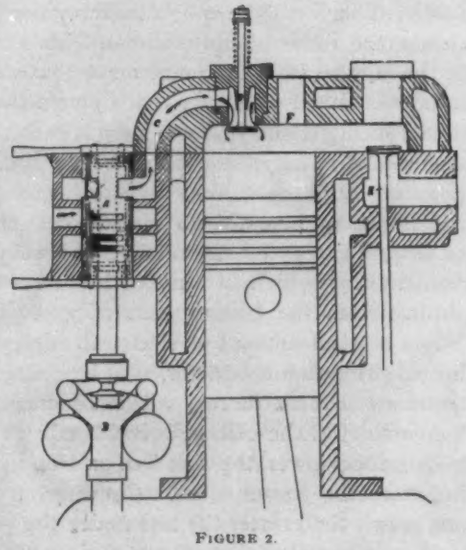

FIGURE 2.

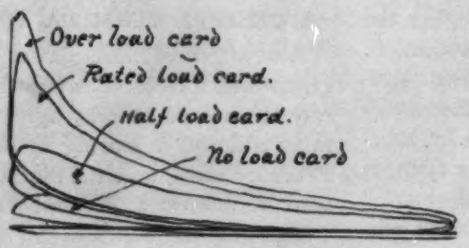

FIGURE 5.

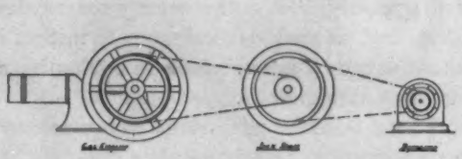

FIGURE 3.

As Figure 3 shows, the gas engine is belted to the pulley on the jack-shaft and from this in turn to the dynamo.

The "hit-and-miss" gas engine must have heavy fly-wheels, and a heavy balance wheel is usually mounted on the jack-shaft in order to obtain an approximately steady speed. I have even seen some outfits of this kind having a small fly-wheel on the armature shaft. This arrangement, as you will see, takes up a great deal of floor space. The flapping of the engine belt, due to the irregular motion of the gas engine, together with the ordinary hissing sound from the two belts, makes the plant a very noisy one. The variation in the voltage on a 100-volt circuit is generally 3½ to 4 volts during the cycle. That is, when the engine may take in a few charges successively the voltage is steady and rising, but when the engine omits one or more charges a momentary variation in speed is the result, and fluctuation is apparent in the lights.

This introduction of two extra belts, shafting, and masses to

*Address before the Technischer Verein (Technical Society) of Pittsburg, Pa.

move causes quite a loss in power. The power absorbed by the two belts will be approximately seven per cent., and by the jack-shaft about three per cent., making a total of about ten per cent. taken up by the extra machinery. Even with this auxiliary machinery the speed of the dynamo is unstable and the service unsatisfactory. This type of engine is, therefore, limited to do work where steady speed is not necessary or required. This type of engine has one advantageous feature, namely, that the charge is always ignited under the same pressure, and hence the actual work done by the exploding gases in a given cycle is practically the same for full load as for no load.

Recent developments have proved that the modern type of gas engine is admirably adapted for electric lighting, as its economy is very high, and its speed regulation in a type to which I shall refer has been made as good as that of a first-class steam engine. It is the electric business which has stimulated the experiments in the direction of producing a gas engine which would be suitable for incandescent lighting work. It is in contrast to the "hit-and-miss" type that I show you illustrations (Figures 2 and 4) of gas engines having the armature on the crank-shaft, direct-coupled, or directly-belted, precisely as its brother, the steam engine.

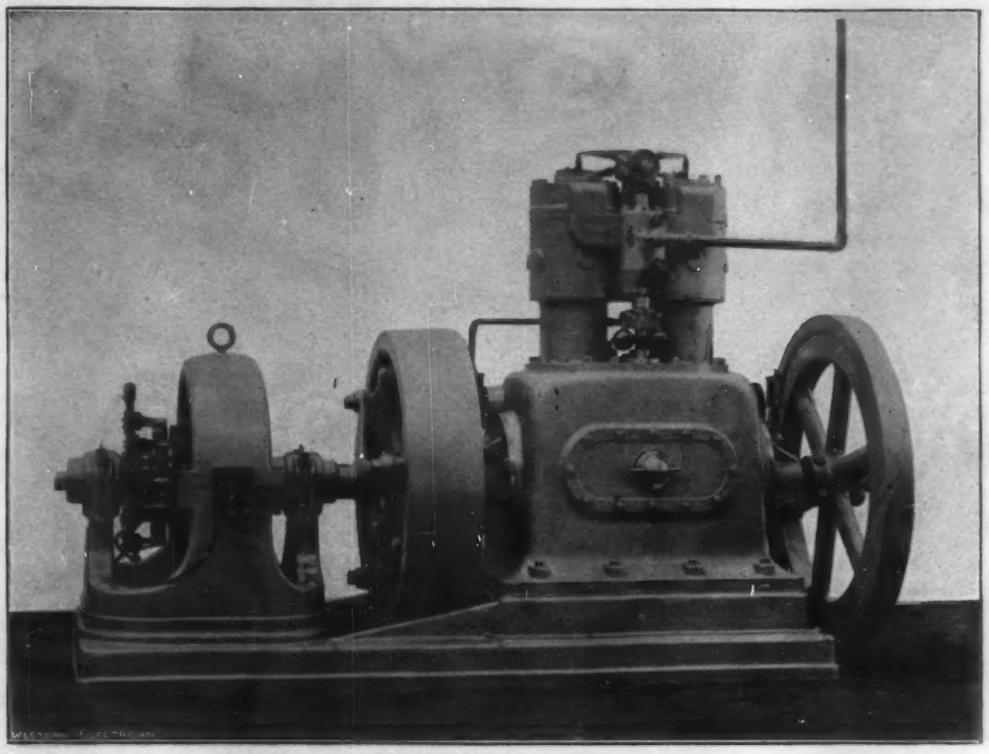

FIGURE 4. THE WESTINGHOUSE GAS ENGINE.

Figure 2 illustrates a gas engine cylinder and mixing valve of the type which proportions the charge in accordance with the load. The gas and air are mixed in the cylindrical mixing valve *A* in the proper proportions at which the same is set. This ingenious device is in reality a proportional meter, and preserves the proportions between the gas and air whether the engine runs at no load or full load. Thus the governor *B*, in connection with this valve, has absolute control over the amount of explosive mixture to be taken into the cylinder through channel *C* and inlet valve *D*. The charges are ignited by an electric igniter, located at *F*. This igniter, which is fully patented by the Westinghouse Machine Company, differs from all other igniters in the respect that it is duplex and the bonnet covers two separate mechanisms. This construction makes it possible to change the connections of the wire from the battery to either set of terminals while the engine is running. If desired, both sets of terminals can be used at one time, thus insuring absolute certainty of ignition. This is often done in large electric station work.

From this you will see that the last-described mode of governing is similar to that of the steam engine, and that for picking up a heavy load it is even in a better position. All charges being proportioned to the load, if the load is suddenly thrown off there is one heavy charge already locked in, which cannot be removed, although the governor acts instantly, and there may be another under way which may be partially reduced by the action of the governor. This tends to speed up the engine a trifle above the normal, but because of the fly-wheels this tendency is so slight that it can be ignored in practice; besides there are very few plants subjected to throwing off the entire load at once. Having described both classes, I shall now dwell upon the gas consumption, and what I say in this respect is applicable only to the Westinghouse gas engine.

The gas consumption in all engines varies with the kind of gas used and also with the size of engine up to certain limits. The average performance of the Westinghouse gas engine, say from 20 horse-power upward, is 10.5 to 12 cubic feet of natural gas per brake horse-power hour. Accord-

GAS CONSUMPTION.

ing to numerous tests with the Junker calorimeter, I have found that the average heat value of natural gas is 1000 British thermal units per cubic foot. That is, the engine requires 10,500 to 12,000 British thermal units for each brake horse-power hour, giving a heat efficiency at the shaft of 25.4 per cent. and 21.3 per cent. respectively. The above are not fancy figures, but represent the everyday performance of the engines while in the hands of the customer.

The indicator cards taken from a Westinghouse gas engine will give the reader an excellent idea of the governing action under overload, rated load, half load, and no load. (See Figure 5.)

Some special engines have been built which have given much better results than the above mentioned, and I have in mind a special 125 brake horse-power gas engine which, when tested, gave the phenomenal economy of nine cubic feet per brake horse-power. This would give an efficiency at the shaft of 28.7 per cent.

These are good results, but they are not as good as may be expected, and I firmly believe that the everyday performance of a gas engine will, within a short time, reach 33⅓ per cent. Some experiments are being made along this line now, and with reasonable show of success. In comparison with this result I quote the gas consumption of the Lenoir engine of 1861, which was practically 90 cubic feet of about 700 heat unit gas per brake horse-power hour. This engine was really the first commercial engine offered to the public. The next step was the Otto-Langen free-piston engine, which in reality was the invention of Barsanti and Mattencci, brought out in or about 1867. According to Tresca, the gas consumption per brake horse-power was 44 cubic feet per hour. In 1876 Otto brought out the so-called "Otto Silent" gas engine. This engine was a compression engine, and in principle not very different from the "hit-and-miss" engine of today. This cycle is called Beau de Rochas, or the Otto cycle, although Gustav Schmidt is probably the originator of it. The consumption of gas was about 30 cubic feet per brake horse-power hour. Thus we can see that the efficiency of gas engines has been notably improved.

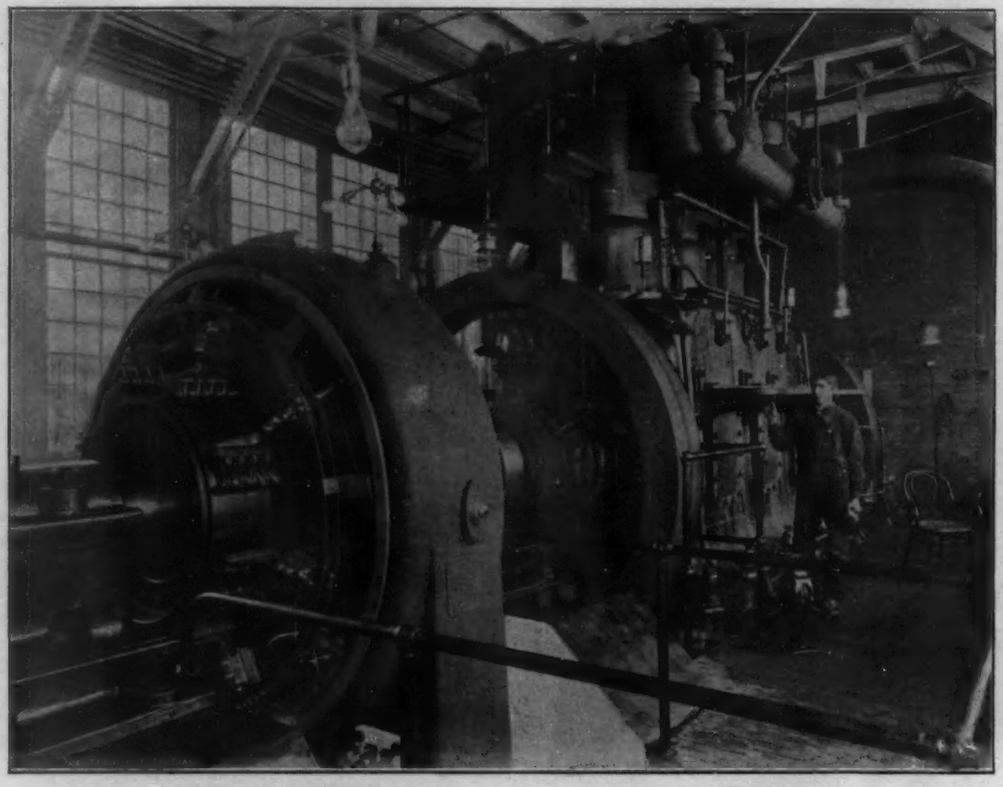

FIGURE 6.—LARGEST GAS ENGINE IN COMMERCIAL OPERATION.

It is necessary in a gas engine to have the cylinders and all the parts exposed to the heated gases water-cooled, in order to prevent over-heating of the different parts. This is generally done by letting a stream of water flow through cylinder jackets. As the public at large seems to be ignorant as to the water consumed per brake horse-power hour, I shall here state the amount of water required. In winter the consumption of water may be put down at about 30 pounds, and in summer 38 to 40 pounds per brake horse-power. In places where water is expensive, this need not be wasted, as by putting up a tank or tanks, according to the size of the engine, the loss of water need not be more than a few gallons per week, or just as much as the evaporation of water from the surfaces of the tanks would amount to. Another way of cooling is by the use of a cooling tower. The water is pumped from a well through the water jackets of the gas engine cylinder, where it becomes heated, and from there over to the top of the cooling tower, to again return to the well at about atmospheric temperature, to be used over and over. This mode of cooling produces a greater loss of water than that of the tank system, but it is almost always used in connection with large sized engines. Not long ago I made some tests for the purpose of determining the amount of water necessary for cooling and to determine the heat lost through the same. It was found that 5121 British thermal units went out in the cooling water, 2922 British thermal units were converted into work, and 2957 British thermal units must then be the approximate amount of heat which went out through the exhaust and was lost by radiation. From this you will see that there is still room for improvement toward efficiency. The bulk of the loss is in the cooling water.

WATER CONSUMPTION.

Until recently the gas engine has been made in comparatively small sizes only, and, as I have before stated, only for what you may call rough work, that is, where steadiness of speed was not essential. The largest engine in this country, made commercially, was only 100 horse-power, having two cylinders and of the "hit-and-miss" type. The public looked upon the gas engine as a sort of "freak," and did not take very kindly to it. The hard times, however, which we have experienced during the last five years or so have done much toward introducing the gas engine. The keen competition and the small margin of profit caused manufacturers and business men to look around for some spot where a saving could be effected in their establishments. An investigation followed which was favorable to the gas engine. The introduction of electricity, calling for prime movers, also stimulated the demand for a cheap and convenient motor, and this, more than anything else, has brought the gas engine forward. When Mr. Westinghouse, about five years ago, commenced experiments in the gas engine field, he did so because he foresaw a large future demand for the gas engine in the electrical field, if it could be made to give the service that its brother, the steam engine, was doing. Experiments on a fairly large scale

FUTURE OF THE GAS ENGINE.

followed, both on compound and single expansion engines. The work was hard and trying, as the obstacles to overcome were numerous, but the results have been gratifying. In the early part of the spring of 1898 an engine of about 650 brake horse-power was completed in the works of the Westinghouse Machine Company. (Figure 6 illustrates this engine operating a direct current, 500-volt engine-type generator.) This engine is of the three-cylinder type and has a speed of 150 revolutions per minute. After it was thoroughly tested on the testing foundation, it was erected in the power house of the Westinghouse company, where it is running in regular commercial service of a severe character.

The engine is direct-connected to a suitable generator and runs in conjunction with one or two steam engines, according to the call on these units for electric current. This engine is by far the largest gas engine in the world, and it is pleasing to record that this large gas engine was built in Pittsburg. But this engine will not long enjoy the distinction of being the largest one. The Westinghouse company is making drawings and patterns for a 1500 brake horse-power gas engine. This engine is also of the three-cylinder type, and it is designed to run at 100 revolutions per minute. Remarkable economy is expected from this engine, as every possible care is being taken to make it a model of modern gas engine engineering. It would not be surprising if this engine developed a brake horse-power for every 8½ cubic feet of natural gas consumed per hour, or 8500 British thermal units per brake horse-power hour. This would give a heat efficiency of $\frac{2564}{8500}$ or 30 per cent. at the shaft. When gas engines can be made of such efficiency in large units, they will undoubtedly compete successfully with the most modern steam engine.

A gas engine of such size and efficiency will run day in and day out on less than one pound of coal burned in a good produce gas plant per brake horse-power hour. This includes banking of fires and the like losses. It would have to be a high-grade steam engine and boiler plant if it should regularly be able to produce a brake horse-power for two pounds of coal per brake horse-power hour, twice the amount of fuel required by the gas engine under similar conditions. From the foregoing you will see that the gas engine is no longer limited to special power purposes. It can hold its own as a prime mover, and can be used for almost all purposes for which the steam engine can be used. But all this has not been accomplished in a day. It is now 108 years since the first patent on an explosive motor was taken out by John Barber, and from that time on it may be seen that great improvements have been made.—*Western Electrician.*

NO STANDARD OF ILLUMINATION.

It is a singular fact that there is absolutely no standard or unit of illumination. An architect or engineer confronted with the problem of lighting an interior, for example, with whatever sort of illumination, has no more reliable criterion to guide him than common experience. His methods of solution will inevitably resolve itself into guess work. He does not know what intensity of light he wishes to attain, and if he did he would not know how to set about procuring it. Heating and ventilation have been reduced to fairly exact sciences in which, at least, there are degrees of intensity and units of measurement; but there is nothing tangible about lighting. The prevailing rule seems to be that a little more than enough light is just about right.—*The Engineering Magazine*, Vol. XVI, No. 6, page 1004.

ELECTROPLATING PREVENTS FOULING OF HULLS.

The electroplating of the hulls of iron ships has been favorably reported upon by officers of the United States Navy Department who state that the hull of the vessel under test was plated with copper in February, 1895, and has been in continuous use since without necessity for cleaning. A current rate of 7½ amperes per square foot, and a difference of potential of 1½ volts are sufficient to deposit a perfectly uniform, smooth, adherent coating.

Illumination

THE LESSON OF A MUNICIPAL FAILURE.*

BY J. H. STALLARD, M. B., LONDON, ETC.

THE facts relating to the lease of the Philadelphia Gas Works have been fully stated and sufficiently discussed by several distinguished writers, but as yet no one has touched upon the real cause of failure or proposed a remedy.

The great advantage of the municipal ownership and operation of gas works can not be disputed, and it is a most lamentable circumstance that the third largest city in the United States, after ten years' experience, has relinquished their control. In spite of all possible explanations, such action must be regarded as a confession of inability to administer them successfully, and an acknowledgment of the superiority of private over public management. This unfortunate conclusion cannot be ignored, and certainly ought to lead to a careful contrast of the two systems, in order to find out wherein they differ, and whether there is any hope of putting municipal gas-work management and the conduct of other public utilities on a private corporation basis. If this could be done, we might reasonably expect the same result.

In the first place, it must be noted that the citizens substantially correspond with the stockholders in a private corporation. In both cases the stockholders may be few or many, male or female, old or young, wise or ignorant, rich or poor. All or none may be endowed with social or philanthropic instincts. Like private stockholders, citizens may constitute a strange and constantly changing medley of Protestants, Catholics, Atheists, Socialists, Democrats, Republicans, Populists, etc. Neither "private" nor "citizen" stockholders expect personal association in the conduct of affairs, but are ready to intrust their interests to their representatives. The main difference consists in the need of residence. Whilst the private stockholder may reside in London, Paris, or Japan, the citizen acquires his interest by residence, and at the same time becomes the consumer of his own productions.

In the next place, the success of corporations is not dependent on the character or social standing of the stockholders, but on the form and constitution of the business government. No large business corporation trusts the management to a single person except when that person owns the controlling interest and would be the greatest sufferer by his own neglect. The very worst proprietary is certain to prefer the election of honest representatives. Whilst the efforts of the most exemplary and most honorable body of stockholders and officials would assuredly fail if the principle of management encouraged the growth of corrupting human weaknesses. Under such conditions the most immaculate officials must eventually become corrupt. From this it follows that corruption in government affords *prima facie* evidence that its form and method must be wrong.

How, then, do private stockholders secure honest and successful management? It is universally acknowledged that there are no two ways. They simply elect a committee of themselves. They elect a corporate body, which they endow with corporate power and corporate responsibility; which determines the policies and the mode of action; which appoints, promotes, and removes all executive officers at its own pleasure, settles their salaries and duties, and the conditions of all employment; which supervises all official acts, regulates all expenditutres, orders all repairs, improvements, and extension of the works, and asks of the stockholders more capital as soon as it may be wisely and profitably employed.

This representative board of directors has absolute and undivided control. No one is permitted to obstruct their deliberations or dispute their action. No one can veto their ordinances nor contract their operations. No one can cancel or postpone the payment of their checks. In the election of a corporate business management, individual power and responsibility are both lost. No individual can have special privileges by right. No one has

*From *The Overland*, February, 1899.

personal power to give an order, make an appointment, remove an official, or spend a cent, without the elected corporate consent. No one has it in his power to promise appointments, contracts or emoluments of any kind, to the friends who have assisted to elect him. No one has "spoils" to give away. Moreover, the board of directors is not permitted to alienate any portion of their power to boards, commissioners, or individuals, over whom they have no absolute control. They are responsible for the fitness and conduct of every officer employed, and can not shift any part of the appointing, promoting, or controlling power on the shoulders of commissioners less qualified than themselves to judge of the merits of the candidates or their special fitness for the duties they are expected to perform. And lastly, the sole and most efficient bond of union is the financial interest of the corporation, and the sole test of success is the profitable return.

If these simple conditions satisfy the requirements of a private corporation, why should they not be tried in city government and in the management of public gas works?

Now, it is remarkable that no successful municipal government can anywhere be found which is not conducted on this simple business plan, and municipal authorities so constituted present innumerable examples of the successful management of gas works. The town of Birmingham, England, is a case in point. It is a large manufacturing town which, like Philadelphia, is engaged in a variety of industries. There are 95,000 citizens who vote, or nearly one-fifth of the population, a proportion equal to that of an American city. The large council elected by the city has complete control; the gas works are managed by a committee of eight members, who submit all their operations for the approval of the council. Their last report presents a sample of their work. They state that additional and enlarged mains are required in districts in which it was found difficult to maintain the supply as efficiently as necessary for gas engines and heating purposes. They report that a bench of retorts had to be reconstructed, and that the adoption of eight instead of seven retorts will require a small expenditure on capital account. They report the acceptance of tenders in connection with the works, and that satisfactory terms have been arranged with patentees for the use of inclined retorts. At the request of the council, they have made arrangements for providing a recreation ground from a portion of land not in present use, and are in communication with the baths and parks committee, who will carry out the scheme. The committee has under consideration a revision of the salaries rendered necessary by more important duties, and in answer to an application from one of the superintendents for an increased salary, they propose to grant him an addition of $250 a year. Their accounts show a profit amounting to more than a quarter of a million dollars. This profit is dealt with in a purely business way. The committee reports that half of the total output is sold to consumers whose demands remain constant throughout the year, and whose consumption it is most desirable to encourage. They report that some of these large consumers are providing themselves with gas-producing plants, and that the price to this class must be reduced to arrest this loss. They therefore request that a reduction of twenty per cent. below the highest price should be made to them. They also recommend that the charge for gas for public lighting be proportionately reduced. They estimate the gross cost of these reductions at $150,000 yearly, which will, it is hoped, be recovered by increased output. It is an error to suppose that the management is authorized to favor any special class, or to set aside financial considerations for the sake of social or industrial progress. They put in connections and fixtures as a pure matter of business to promote gas consumption. They introduce penny-in-the-slot machines to extend the use of gas amongst classes who are unable to use it on any other terms; they rent out gas stoves to those only who cannot afford to buy them; and in order to meet the financial conditions, they raise the price to all these small consumers.

Throughout the report of the committee there is no mention of the manager, who is not permitted to share in any part of their responsibility. He is simply the servant who is paid for his technical skill, his advice, and his executive ability. For the due exercise of these he is immediately responsible, and would be discharged for failure. He recommends candidates for employment, but cannot appoint them. He recommends the purchase of materials, but has no power to order them. He proposes new processes, but cannot introduce them, and new machinery of production without the power to construct it. Thus is the power of the executive kept under corporate control, and the separation between legislative and executive functions made complete. From this example, which is one of hundreds, it becomes evident that the same form of business management which is found in private business corporations will surely succeed in the management of public utilities under municipal control.

If we examine the municipal governments in American cities, we find that all the characteristic features of private corporation management have completely disappeared. Corporate wisdom is no longer regarded as the test of safety. Corporate power is overwhelmed by individual power. Corporate responsibility is despised, and is replaced by that of individuals. And all this in spite of the accepted principle of all good government, which affirms that no individual action can possibly replace the concerted action of the people, who are necessarily most interested in successful government.

It is discretionary individual power which is the source of every kind of abuse and destroys responsibility. It is therefore one of the first duties of a business government to define its limits, and the duty can never be left to the judgment of a single man. No nation can be properly governed by a king or emperor, and all great business corporations are conducted by corporate authority. The government of the complicated activities now demanded by the citizens assuredly belong to this category, and must therefore be intrusted to representative corporate control.*

No capitalist would venture to invest his savings in a gas works with a management constructed on the lines of the Philadelphia government. Instead of a body of representative directors, upon whose corporate wisdom and honesty he has been accustomed to rely, and to which as a body, and not to any individual, he has given unlimited and undivided power over the company's affairs, he finds an emasculated creation, falsely dignified with the name of council, which has been constructed under the power of an immutable charter, from which there is no possible escape, and which curtails freedom of action in every possible direction. Unlike the construction of a private business corporation, the charter of Philadelphia forbids the council to appoint the president or mayor, who is elected by the people, not as the servant of the council, but as its master. This official is an ingenious complication of legislative and executive power. As official chairman of the council, he is the head of the legislative body, and in this capacity he largely controls the course of business and the subjects of deliberation. Without his assistance there can be no budget. He must approve of all appropriations. His consent is specifically required to complete every act of legislation; and above all he exercises the power of the veto, which is alone sufficient to modify the whole course of legislation and expenditure. Short of giving him imperial authority, it seems impossible to confer more legislative power upon a single man. But besides this, the charter makes the mayor the central figure of the executive. He appoints the heads of the six departments who form his cabinet and are supposed to be responsible for the conduct of the gas works. Here, then, we have in the person of the mayor that intimate combination of legislative and executive power which is denounced by the Hon. Seth A. Low and every statesman in the world. The logical conclusion is that one or the other of these functions must be given up. If the mayor is still to be the executive center, he should be retired from the council, like the President of the United States, and if he remain a councilor, he should be relieved of his executive functions. In a private business corporation the president is simply chairman of the council, and exercises no ex-

*See *The Overland*, March, 1897.

ecutive functions without their approval and authority. To get a business management in Philaelphia, it will be necessary to destroy the power of the mayor.

In the next place, the investing capitalist would be astounded to find that the elected corporate body cannot be trusted to appoint the gas works manager. In Philadelphia the mayor appoints a director of public works, who in turn appoints the chief of the gas works. The chief of the gas works again in turn appoints an army of deputies, superintendents, mechanics, clerks, coal-heavers and other workmen. He spends more than a million annually in salaries and wages, and is thus enabled to barter the appointments with the individual councilors to attain higher wages and more appropriations for his henchmen, and with outside political bosses for the electoral support of his patrons. Thus is created one of the most powerful political machines to be found outside of Tammany. In all these arrangments the corporate power of the council is utterly ignored. The manager of the Philadelphia gas works is in fact the boss. The council are supposed to be utterly ignoraut of gas making. The corporate wisdom of the council is not in it. The council does not determine the policies of action. It does not appoint the engineer and chemist, or settle the kind and quality of gas, the mode of manufacture, or the nature and cost of the machinery. None of the thousand practical questions which are submitted to and determined by the equally ignorant business directors of a private gas corporation are submitted to the council of Philadelphia. The council has no practical interest in the management, and no real responsibility. No wonder, therefore, that it seizes upon all seeming profits, not with the object of providing for depreciation or extension of the works, to meet the demands of the increasing population, but to promote the false policy of currying favor with the customers, by reducing the price of gas and the taxes of the citizens. But the charter interference with the management does not end here. The charter provides for the separate election of an auditor, with powers nowhere to be found in any private corporation. Business and English municipal auditors examine the books and compare them with the vouchers and cash balances, and report the result to the council and the public. But American municipal auditors, whilst they would be compelled to sign the account of a contractor charging double prices by order of the council, or on the demand of a gas works manager, who secretly receives whisky and jewelry in the place of coal, are obliged to examine every bill presented by the council and sign it before it can be paid. The poor council can not be permitted to sign its own honorable checks without the assistance and approval of the auditor.

Again, who ever heard of directors of a private corporation not trusted with the care of cash? No such official as an elected treasurer is to be found anywhere in the whole world outside of an American city government.

The same remark applies to the tax collector, or chief clerk, and recorder. Corresponding officials are all appointed by the directors of a private corporation, and are removable at their pleasure. All municipal officials in America are endowed with discretionary and executive power. Indeed, the admixture of the two is adopted as the principle in the New York charter. "Whenever," said the charter-makers, "the work of the department is principally discretionary (legislative), a board has been provided, and whenever a department is chiefly executive, a single commissioner has been provided." This discretionary power enables both boards and individuals to take care of their relatives, friends, and political acquaintances, and subjects the best-intentioned and most honorable men to "pulls" and other evil influences, which make official life repugnant to them, and turns it over to the venal and corrupt.

It seems that an angelic constituency would be unable to secure the successful management of gas works or any other public utility with such machinery of government; and that it is simply absurd to put the blame of failure on the absence of social ideals or the want of public spirit of the citizens. The citizens of America are better instructed on public questions than any in the world, and take a more active interest in what is going on. Public opinion is both sound and strong, and if it could have acted, the existing municipal institutions of America would have been swept away long ago. From a long acquaintance with the cities of England, and a residence in San Francisco of a quarter of a century, I can testify that the citizens of all large cities are substantially the same in character, and that in all there is a crowd of honest citizens ready and willing to give their time and services in the honorable service of the public. But the essential condition is that they shall be elected and treated as trustworthy and honorable men, no law being adequate for the control of rogues.

Happily, the citizens of America are beginning to realize the evils of private corporate monopoly and the impotence of municipal authorities to resent their encroachments on our purses and liberties. But they have yet to learn that private corporate monopolies can only be met by the municipal adoption of private corporate methods, and that in the competition thus established the public power will certainly prevail.

No private gas corporation can possibly exist in Birmingham, not because the citizens sentimentally object to them, for assuredly they have no such prejudice,—indeed, there are hundreds of other private corporations in the city—but because the municipal authorities are able to provide the necessary capital at a lower rate of interest than a private corporation, and can also secure the services of the most accomplished experts and erect the best machinery. Therefore, on these accounts, they are able to supply their customers with better and cheaper gas.

The reform of American city government is not a matter of evolution by the methods now in operation. This evolution is on the way to failure, of which the probable acme is the New York charter. It is only through simple deduction, *a priori* reasoning, and actual experience throughout the world, that the conclusion becomes irresistible that the honest adoption of simple council government, founded on the model of all business corporations, affords the only prospect of successful city government. This system has never once been tried in any city of the United States, where municipal institutions are a conspicuous failure, whilst elsewhere it affords examples of success in every quarter of the globe. The crowning advantage is that it removes from municipal government the curse of personal power and patronage, which is the basis of corruption and the food of political machines.

EVEN ACETYLENE IS VERY INEFFICIENT.

It is not generally known that the theoretical limit of attainable candle-power from acetylene, made from calcium carbide produced in an electric furnace, is somewhat less than that actually obtained from incandescent lamps actuated by the same amount of electrical energy. As a matter of fact, a given quantity of light produced by burning acetylene necessitates today an expenditure of from two to three times as much energy in making the carbide as would be required to generate the same light with incandescent lamps. This difficulty is only apparent, however, because inexpensive water power can be used for making the carbide, which may be transported to any distance. In a sense, calcium carbide represents the stored light-producing ability of the energy used in its manufacture.—*The Engineering Magazine*, Vol. XVI, No. 6, page 1004.

EFFICIENCY OF ILLUMINANTS.

A leading authority gives the following as the energy, expressed in watts, required to produce light equivalent to one candle-power as measured by the English standard candle:

	WATTS.		WATTS
Tallow	124	Cannel gas	48
Wax	94	Incandescent electric	3.5
Spermaceti	86	Nernst lamp	1.5
Mineral oils	80	Incandescent gas	1.2
Vegetable oils	57	Arc lamp	.3
Coal gas	68		

Clark's compound: mineral pitch 13 parts, sand 6 parts, tar 1 part.

Trade Literature.

Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY. Where addresses are not given, they may be found through refereuce to the Advertisers' Index on page iii.

"Long Burning Arc Lamps." Bulletin No. 2, illustrating and describing the latest or "P. Q." type of enclosed arc lamp for direct current circuits. *Pacific Arc Lamp Company*, 149-155 Fremont street, San Francisco.

"American and Foreign Patents." A popular discussion upon American and foreign patents, trade marks, interference cases, copyrights, etc., together with costs of service. *J. Richards & Co.*, 22 California street, San Francisco.

"Endoscopic Lights." A 32-page brochure, well illustrated, describing the electrically-lighted instruments and attachments for physicians, surgeons and dentists, as manufactured by the *American Endoscopic Company*, Providence, R. I.

"Otto Gas and Gasoline Engines." Two separate pamphlets on gas and gasoline engines of the famous Otto type and manufacture. Illustrations, descriptions and dimensional data are included. *Henshaw, Bulkley & Co.*, agents, 48 Fremont street, San Francisco.

"Transformer Design and Operation." No. 9064. The second valuable production on the use and abuse of transformers for local distribution, and so important, if not vital, are the suggestions therein given that the book should be digested by all station managers. 38 pages, 8x10¼ inches. *General Electric Company.*

"The Stirling Water Tube Boiler." A 24-page pamphlet illustrating the principles of operation and some of the noteworthy installations of the Stirling boiler, and briefly setting forth its advantages. *The Stirling Company*, Pullman Building, Chicago, or the *Pacific Coast Machinery Company*, 12 Fremont street, San Francisco.

"The John M. Klein Electrical Works' General Catalogue No. 20." A 140-page catalogue of electrical supplies of every description, profusely illustrated, and containing many tables and much useful information. Issued by one of the oldest and most reliable houses on the Pacific Coast. *The John M. Klein Electrical Works*, 421-423 Montgomery street, San Francisco.

"Filing Cabinets and Business Furniture." No. 26. Caters to the office needs of business men of every complexion, with an infinite variety of filing cabinets and general mercantile furniture which, once possessed, would be held as indispensable. The "card system," as therein described, has evidently been worked out to perfection. 160 pages, 6x9 inches. *The Globe Company*, Cincinnati.

"Ice-Making and Refrigerating Machinery." About 100 pages, in coat pocket size, of information concerning refrigeration processes. Ice-making plants from a capacity of 150 pounds of ice up to many tons per day, as well as refrigerating machinery for rooms 8 feet square up to great abattoirs and packing houses, are discussed with a degree of satisfaction seldom found in a trade catalogue. *Oakland Iron Works.*

"Windmills, Pumps, and Gas Engines." Catalogue No. 26. 88 pages, freely illustrated, giving descriptive price lists of various types of steel and wooden windmills and pumps, as well as of the Webster gas engine. Though this catalogue is very complete, it seems surprising that it should contain no reference to windmills geared for power purposes other than pumping. The book is invaluable for the farm and country. *Woodin & Little*, 312-314 Market street, San Francisco.

"The Modern Roundhouse Turntable." Showing, in an artistic manner, the high degree of serviceability which the electric motor has attained in the operation of turntables for standard railways. The Westinghouse method of applying electricity to the operation of turntables should be especially interesting to railroad managers, inasmuch as it requires no change in the turntable proper, other than attaching the draw bar lug to the turntable girder. *Westinghouse Electric and Manufacturing Company.*

"Thomson Recording Wattmeters." Ten years ago electrical energy was invariably supplied at a fixed rate per month for each installation without much regard to the amount actually furnished. Today electric stations in this country supply on a meter basis the electricity they manufacture with resultant advantage to the station economy. Some idea of the extent to which the meter business in this country has grown may be gathered from the fact that not less than 200,000 Thomson recording wattmeters alone have been manufactured and sold by the General Electric Company. The business has grown from small beginnings by the persistent missionary work which has been carried on by this company through both agents and literature. The latest addition to the meter literature issued from the General Electric press is "Thomson Recording Wattmeters," a handsomely printed and illustrated brochure in a rich cover, dealing with the different types of these recording energy meters which the General Electric Company manufacture, their uses and their advantages. Each type of motor is clearly described and so illustrated that its construction can readily be understood. Full instructions are given for the care, connection and reading of these meters. The pamphlet should be found in the library of every electric light and power station, and will be sent on application made to the Schenectady office of the *General Electric Company.*

The Southern Electrical Company has just opened a large supply house at the corner of Third and South Main streets, Los Angeles. The company carries everything electrical and has one of the largest and most complete stocks in southern California.

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